FreeClimber: Analyzing Steep Terrain and Subsurface Habitability on Mars and Earth

Completed Technology Project (2014 - 2018)

Project Introduction

We propose to integrate three habitability instruments onto a rock-climbing robot. The system will perform vertical transects on canyon walls in Death Valley, CA, pit crater walls in Volcanoes National Park, HI, and lava tube walls and ceilings in El Malpais, NM. These field campaigns will demonstrate the cross-cutting applicability of the system to both human and robotic missions to Mars, our Moon, and small bodies. Key drivers for these areas include understanding mineralogy, characterizing the potential geochemical gradients, creating an inventory of elemental abundances, inferring the current or past evidence of water and the emplacement of soluble materials. This effort will achieve high fidelity in all three fidelity areas, science, technology, and science operations. Remote observations of Mars have identified remarkable geologic regions with features including large canyons like Valles Marineris, apparent skylight entrances to lava tubes in the Tharsis region, and massive-scale fissures of tectonic or volcano-tectonic origin, like those at Cerberus Fossae. Observations of unreachable but distinct strata in exposed crater outcrops by the Spirit and Opportunity rovers sparked the community's interest in these high value targets. A vertical transect of these large, exposed sections of rock would provide a unique opportunity to characterize the stratigraphic column in proper context and effectively look back into the history of Mars and investigate the habitability of the planet. Motivated by this, rock climbing robots that utilize a unique gripping technology called microspines have been in development at JPL for several years, and the LEMUR 2 platform was recently field-tested climbing vertically and fully inverted at lava tubes near Pisgah, CA. The technology has also been demonstrated acquiring rock cores regardless of gravitation orientation (i.e. drilling into the ceiling). In this work, the robot will carry and deploy three habitability instruments as well as a pair of stereo-cameras for both navigation and the creation of 3D maps of the terrain. The robot will host a micro X-ray fluorescence instrument (Micro-XRF- a predecessor to PIXL) developed by Co-I Abigail Allwood and team that will provide elemental abundances of the rock materials. These lithochemical measurements enable interpretation of the local geology to help determine habitability and search for evidence of life. A second instrument developed by Co-I Rohit Bhartia and team uses morphological imaging with spatially correlated, deep UV fluorescence/Raman spectroscopy (GURILA- a predecessor to SHERLOC) to rapidly image bacterial communities in their native state on opaque materials. Prior demonstrations have targeted extremophile lifeforms from nutrient-limited environments such as the terrestrial subsurface. Third, a near-infrared acousto-optic tunable filter based point spectrometer (PASA) developed by Co-I Nancy Chanover and team operates over a wavelength range of 1.6 to 3.6 μm, diagnostic of minerals and organics. PASA is designed to detect organics or organically modified minerals via their spectral signatures. Co-I Penny Boston and team study planetary caves and terrestrial analogs and have recently pioneered the identification and study of biofabrics and biovermiculation (tubular structures created by microbial mineral mining) that could be used to detect past microbial

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Organizational Responsibility

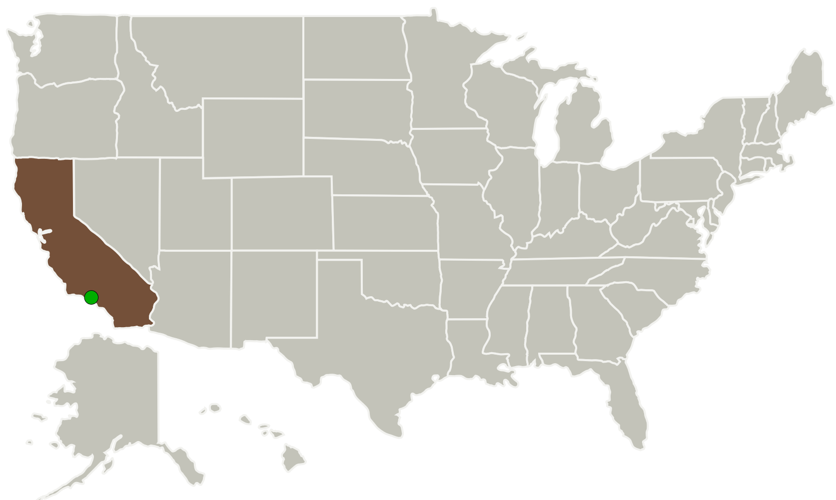
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Planetary Science and Technology Through Analog Research alteration of surfaces. Mounting evidence of an extensive microbial biosphere on Earth that is highly biodiverse and can exist on a variety of inorganic energy sources is encouraging for the search for life on Mars's extreme terrain and subsurface. On Mars, the steep slopes and subterranean areas naturally protect life from radiation, and this is a likely place to find extremeophiles. The public appeal of these strange Earth or Martian lifeforms being discovered by a videogenic, rock climbing robot deep in a cave or high on a cliff wall will be extraordinary.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Management

Program Director:

Carolyn R Mercer

Program Manager:

Sarah K Noble

Principal Investigator:

Aaron J Parness

Co-Investigator:

Karen R Piggee

Technology Areas

Primary:

- TX04 Robotic Systems
  - └ TX04.3 Manipulation
    - └ TX04.3.4 Sample Acquisition and Handling

Target Destination

Others Inside the Solar System